Thesis for M.D.

A study of Malaria and measures for its abatement amongst rubber estate workers in the Federated Malay States.

G Waugh Scott M.B.

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

A STUDY OF MALARIA AND MEASURES FOR ITS ABATEMENT AMONGST RUBBER ESTATE WORKERS IN THE FEDERATED MALAY STATES.

The investigations described in this report were carried out during a period of ten years - 1910 - 1920 - whilst the writer was employed as Medical Officer to a group of estates situated in Perak, Federated Malay States.

The area under supervision comprised approximately 14,000 acres of plantations situated in a hilly inland part of the State.

On these properties there was a labour force of approximately 4,500 coolies of the Tamil race, natives of Southern India.

In addition there was a large and fluctuating labour force of Chinese but these were mostly employed on contract terms by their own countrymen and so did not come so directly under the control of the medical department. For that reason the statistics and conclusions here in recorded refer chiefly to Indians.

The Chinese have strong racial prejudices against Western medicine and unless under compulsion they will, in most instances, rely on their own methods of treatment. These are mostly crude and ineffective enough but they understand the value/

value of mercurial aperients and are adepts at various forms of local counter irritation, chiefly of a mechanical kind, which must considerably alleviate the sufferings of the victim of ague.

In prophylaxis the Chinese are much ahead of most Oriental races.

The mosquito net is considered by them to be as essential as a roof over their heads. The Chinaman also boils all water before drinking it which he does in form of a weak brew of tea. They also take a liberal diet even when this involves the spending of practically all their earnings to procure it.

The Chinese coolie seems to realise that his health is his capital, and to know better than most Orientals the means whereby it may be preserved. It is a common observation on malarious estates that Chinese can live and work in lines where Tamils cannot be kept on account of sickness. These facts do not render the Chinese less suitable generally as material fot a study of malaria, but on the estates of which I had medical charge they were not sufficiently under discipline nor did they constitute a sufficiently stable part of the labour force for the provision of accurate figures.

Malaria is endemic in the Malay States, and in many localities, of which this is one, it may be regarded as pandemic. The importance/

The importance of the disease in such areas is difficult to realize by those who have not worked in them. The ubiquity of the disease, the protean forms which it assumes, and the many insidious bad effects which it produces on both sexes and at all ages give it a prominence in the eyes of the medical worker which makes other ailments pale into relative insignificance.

The incidence of other serious diseases amongst a community where malaria is prevalent is about the same as elsewhere but the mortality is invariably higher since not only must the patient resist the toxins produced by the specific disease from which he is suffering, but must also, more often than not, deal with the severe and repeated intoxication produced by sporulating malaria parasites. Even if such patients escape an actual attack of fever during their illness their general physical condition makes their resisting power of the poorest. At times of physiological strain or crisis in women such as menstruation, pregnancy, parturition, lactation, etc. malaria exerts a pernicious influence and becomes an important factor in reducing the birth rate and in raising the infantile death rate.

The well marked tendency for malaria to become active whenever the general bodily resistance is lowered sets up a vicious circle of disease which keeps the afflicted labour force/

force in a sickly semi-invalid state causing much misery, besides serious financial loss to the estates. The salubrity of any estate is directly proportional to the amount of malaria which prevails amongst its population.

In order to obtain precise statistics regarding the epidemiology and results of prophylactic and other treatment a system of card index was devised for malaria cases. The card was as shown under. At the left top corner is a space for the index register number followed by ruled off spaces for the patients name, age, sex, class of work on which engaged, Devision of Estate on which he lives and Date of Arrival on the Estate.

The question of class of work is important as showing whether the occupation has any effect on the incidence of the disease.

Underneath is a larger space in which a general description of the patient can be entered. This includes a short descriptive account of the physical features, notes of any obvious abnormality in the blood condition, liver, spleen, or other organs, together with some definite mark of identification. The last mentioned entry is necessary because of the substitution and changing of names for purposes of fraudulent impersonation which is a fairly common delinquency amongst Tamil coolies.

The/

No. in Register

NAME.	AGE.	SEX.	WORK.	DIVISION.	DATE OF ARRIVAL.

O. OF	ADMITTED.	DISCHARGED.	SYMPTOMS ON ADMISSION.	DIAGNOSIS.	NOTES.

NOTES.

NO.	ADMITTED.	DISCHARGED.	SYMPTOMS ON ADMISSION.	DIAGNOSIS.	NOTES.
2nd.					

The rest of the card is ruled off in spaces in which particulars of each admission to hospital can be recorded. Each space has a printed heading with divisions for "Number of admission" - 1st. 2nd. etc. "Date of admission", "Date of discharge", "Symptoms", "Diagnosis", "Notes". The cards are spaced on both sides giving the record of five admissions, and continuation cards can be added if required.

On admission to hospital the patient's name was entered in an alphabetical register and an index card and number alloted to him.

This card was filled in as described above and kept at the hospital.

In this way an accurate and moderately full account of each patient's medical history as regards malaria was obtained.

RELAPSES.

The first question to be investigated by this means was that of relapses. A very short experience of recording by means of card index served to show that a high proportion of the admissions to hospital for malaria were relapsed cases. This is particularly evident when the infecting parasite is Plasmodium Vivax causing the Benign Tertian variety of fever. This form of parasite tends to produce recurrences even when the patient is treated and the latent intervals show a remarkable/

remarkable uniformity of duration. Infections of Plasmodium Falcifarum and P. Malariae less commonly relapse and the period between such attacks as do occur are not of uniform duration.

The periodic recurrence of the paroxysms of fever during an attack of malaria is a classical symptom of the disease but a periodicity in the incidence of relapses has received less notice yet it is the more regular and striking phenomenon of the two when a case of Benign Tertian is studied over a long period. The period of latency in an ordinary treated case of Benign Tertian is about three weeks. The limit of variation seems to be between 18 and 26 days. The uniform length of this latent period in those cases whose cards show a number of admissions is remarkable.

Thus card number 212, Joseph, a tapper, aged 30, Christian Tamil, shows 12 admissions, Plasmodium Vivax found on eight occasions. The average interval between admissions for the total number is 21 days and on six occasions the interval was exactly that number of days. His later admissions were at shorter intervals but he was then the subject of experiments in treatment to be mentioned later.

The following table shows some typical cards of Benign Tertian cases giving the total number of times admitted and the average latent intervals in days. Only those cards have been/

been selected which gave a record of four or more admissions and which show the diagnosis to have been confirmed by a positive finding at each blood examination. No cards are included which record mixed infection or where one parasite has been found at one admission and a different parasite at some subsequent examination.

Card Number.	Number of Times admitted.	Average interval in days between admissions.
278	4	23
212	12	21
86	6	22
90	5	26
108	5	19
329	8	20
135	12	21
168	10	23
331	5	26
119	7	28
171	11	18
175	9	21
172	10	28
181	8	25
63	11	24
219	5	28

Card Number.	Number of Times admitted.	Average interval in days between admissions.
184	8	21
94	7	19
178	10	25
314	6	19
37	10	25
73	7	19

In this table it will be noted that these cards which show the greatest number of admissions also show a latent interval nearest to that which I have given as the normal period i.e. three weeks.

When one considers the many factors tending to vary the length of interval between admissions to hospital the degree of uniformity recorded is striking. Thus a coolie who develops an ague half an hour before the muster hour can, and probably will, go to roll-call and so get registered for a day's wages. He will, most likely, return to the lines early in that day and the next being free from fever he will again go out so that it may be three or more days ere he is admitted to hospital. The system which prevails on most estates of giving a few days leave to good workers without requiring them to report to hospital also causes temporary concealment of illness. Another factor tending to produce an irregular interval is the lowering of/

of bodily resistance produced by inebriety and other excesses owing to the liability of latent malaria to become active under these circumstances.

A large experience of the treatment of the Benign Tertian type of infection in European patients confirms the evidence given by the card record, as to this regular recurrence of attacks.

In all cases where this parasite is found in the blood it is a routine practice to warn the patient of the danger of a recrudesence of the fever at the end of three weeks and to advise that quinine be regularly taken for that period. This regimen is usually not strictly followed but even if it is recurrence is the rule. So exact to the predicted date is this reappearance of fever that one may get credited with that gift of prophecy so highly esteemed in a physician by some patients. While not amounting to evidence of mathematical exactitude in h the duration of the latent interval, the figures quoted point to definite periodicity in the recurrence of attacks in simple Benign Tertian infections.

Investigations were made in order to determine the relative importance of new infections, reinfections and relapses in the causation of admissions to hospital for malaria.

Where the opportunities for reinfection abound, as they do in a malarious locality, the question as to whether any one attack/

attack is due to a relapse or to a new infection by the same type of parasite is difficult to decide. Uniformity in the duration of the latent period shown over a number of admissions, as in the Benign Tertian cases instanced above affords evidence that relapses are responsible for a considerable proportion of the sickness caused by malaria since it is hardly possible that a series of reinfections could produce such a result.

In the case of sub-tertian, quartan and mixed infections, recurrences are usual but the latent intervals vary greatly in duration and the question cannot be settled by a study of the record of these.

In order to obtain some data on this point the records of 5000 malaria admissions were taken and classified according to the number of times they had been admitted. They are divided into five categories as follows:-

First admissions, Twice admitted, Three times admitted, Four times admitted, and Over four times admitted.

In this series 2,432 or 48.62% were first admissions.
992 " 19.82% had been twice admitted.
791 " 15.82% had been three times admitted.
437 " 8.72% " " four " "
348 " 6.96% " " over four " "

While/

While one cannot be certain that all these classified in the first category were new infections it is safe to assume that the great majority of them were.

A small proportion of these labour forces is made up of coolies recruited locally and these may be infected at the time of their being taken on. The coolies received direct from India can be assumed to be free of malaria on arrival and over 90% of the first admissions recorded in the table would be due to the infection of such newcomers.

This analysis then shows that approximately one half of all hospital cases of malaria were due to new infections, the balance consisting of relapses or reinfections. The proportion which reinfections bear to relapses in the causation of readmissions cannot be proved exactly for the reason given above but an estimate may be made from the number of cards showing double infection. In one series shown below the percentage of mixed infections reaches 33% of the total examinations. If this be added to the 50% of new infections it gives a total of 83% due to new infections and reinfections. It would appear therefore that despite its chronicity and the tendency to relapse, pointed out in the case of simple tertian, it is the prevalence of the infecting agent which keeps up the supply of malaria cases

In this statement it is assumed that all cases showing mixed infection are the result of more than one infective anopheles bite.

Roubaub[1] has shown that a single anopheline may harbour more than one type of sporozoite at a time, but it must be quite exceptional for both types to be present in the salivary glands of the insect simultaneously. In the experiment he reports the dissection showed sporozoites of Plasmodium Falciparum in the salivary glands and sporocysts of Plasmodium Vivax in the wall of the stomach.

The same author has shown[2] that sporozoites in the salivary glands of an anopheline mosquito are practically all discharged in the course of four or five bites and that any remaining afterwards undergo degeneration.

The different periods required for the development from the sexual to the sporozoite stage in the mosquito by the three types of parasite is another factor which would render a mixed infection by one bite most unlikely.

1. Recherches sur la transmission du paludisine par les anopheles francais de regions non palustres. Ann. Inst. Pasteur 1918. Vol.32. No.9.
2. Disparition du pourvoir infectant chez l'Anophele plaudeen, au cours de l'hibernation. C.R.Acad. Sci. 1918. Feb.11th., Vol.166. No.6.

RELATIVE PREVALENCE OF THE DIFFERENT INFECTIONS.

The following table compiled from the total number of positive blood examinations shows the percentage incidence of the various infections:-

Plasmodium Falciparum only - Subtertian 42.54%

Plasmodium Vivax only - Benign Tertian 40.83%

Plasmodium Falciparum & Plasmodium Vivax - Mixed Tertian..14.66%

Plasmodium Malariae - Quartan 1.95%

The combined Benign and Sub-tertian is the only mixed infection commonly met with in these parts. This analysis of the total figures shows practically equal numbers of the Sub and Benign Tertian type but a study of the records from individual estates affords evidence that the percentage incidence of the various forms of fever varies in different localities. Thus taking two of the principal estates distant about six miles from each other the microscopical findings show.

No.1.
Plasmodium Falciparum - 56.99%. Plasmodium Vivax - 32.25%

No.2.
" " - 13.49%. " " - 52.76%

No.1.
Mixed P.Falciparum & Vivax - 2.15%. Quartan - 8.6%

No.2.
" " " " -33.12% " - 0.61%

A/

A survey of the anopheline breeding places on these estates was made by an expert entomologist[1] so that it is possible to corelate the infections and the carrier mosquitos found.

At No.1 Estate the carrier most often found was the A.Maculatus.

At No.2 A.Fuliginosus, Sinensis & A.Barbirostris were those most often often met with. This is in accord with the usual experiance of workers in this country that malaria is most prevalent and of the most severe character in those places where the A.Maculatus is most abondant. This mosquito breeds in fresh water and shows a preference for small clear hill streams and seepage water in open situations where there is no shade. So consistently has this relationship between Maculatus and malaria been observed that in all except the flat coasted areas in which this mosquito does not breed, anti-malarial effort is concentrated mostly on the elimination of this carrier alone.

It is found that the incidence rate of malaria falls in proportion as such elimination is successfully accomplished.

The/

1.Dr.C.Strickland, Government Travelling Medical Entomologist, Federated Malay States.

The following extracts from the literature shows the percentage proportion of the various infections found in some other parts of the world.

I. Andruzzi working amongst Italian troops on the Albanian front found 98% of the cases were sub-tertian and only 2% due to Plasmodium Vivax.

2. Soulie (Henri) among 436 cases treated in hospital in Algeria found 63% Sub-tertian, 31% Benign Tertian, 3% Quartan and 1.6% mixed.

3. Q.H.Richardson on the Shatt el Arab river had 87% Benign Tertian and 13% Sub-tertian.

4. Braun in a very large number of cases among the troops in Morocco found 66% Benign tertian and 34% Sub-tertian.

5./

I. Andruzzi (A) Le forme parassitarie malariche predominanti fra le truppe sul fronte Albanese Ann.Med.Nav e Colon 1916. Vol.2. No. 5 - 6.

2. Soulie (Henri) Traitement du paludisme. Bull.Soc.Path. Exot. 1917. Mar. Vol.10. No.3. pp. 217 - 247.

3. The Shatt el Arab river with special reference to malaria Je Roy, Nav.Med.Service No.1. Vol.3.

4. Braun. Le paludisme au Maroc en 1915. Maroc occidental. Arch.de Med. et de Pharm.Milit. 1916 Nov. Vol.66. No.5. pp. 593 - 645.

5. Leger in Ceyenne investigated the incidence of the infections at various seasons and found the figures to be:-

December to March..	Sub-tertian	52.9%	Benign Tertian		42.6%
April to July.....	"	62.8%	"	"	34.2%
August to December.	"	62.8%	"	"	33.9%

The percentage of Quartan at the various periods was:-

December to March. 4.4%

April to July.....3.6%

August to December.....2.9%

6. The Russian Commission during an expedition to the Black Sea region found Plasmodium Falciparum.....36.7%

Plasmodium Vivax.....42.4%

Plasmodium Malariae.....37.1%

7. Russell investigating relapsing cases in the Panama Canal zone found:-

Sub-Tertian.....45.2%

Benign Tertian.....47.8%

Quartan..... .6%

These figures obtained from widely separated parts of the world show considerable uniformity.

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5. Leger (Marcel) Documents em atologiques relatifs Paludisme a la Guyane Francaise - Bull.Soc.Path.Exot.1918.Feb. Vol.11. No.2. pp. 67 - 73.

6. Work of the commission for the study of malaria in Russia.Vol.2 No.4.

7. Fredrick F.Russell. Relapses in Malaria. Proc. Med.Assoc. Canal Zone. Vol.9.

The comparative rareity of the Quartan infection is remarkable though there are areas in this country in which this appears to be the predominant type. Dr.Hacker, Director of the Anti-malarial Bureau, Federated Malay States, found in the course of his enquiry into malaria at Perhentian Tinggi that of those examined 33% were infected by Quartan Parasites, and he himself contracted that infection while working there.

6. Work of the commission for the study of malaria in Russia. Vol. 2. No.4.

7. Frederick F. Russell. Relapses in malaria. Proc. Med. Assoc. Canal Zone. Vol.9.

COMPARATIVE CHRONICITY OF THE VARIOUS INFECTIONS.

An indication of the comparative chronicity of the various infections was obtained by finding the average number of times cases of each type had been admitted. The following are the figures:-

Type of infection	Average number of times each case was admitted.
Sub - tertian only	1.75
Benign tertian only	3.76
Mixed Benign & Sub - tertian	5.48
Quartan	1.37

These figures very accurately reflect the impression one gains/

gains from experience in treating a large number of cases. In uncomplicated Sub - tertian if treatment is vigorous and the patient can be protected from adverse physical conditions or devitalizing influences after his discharge the danger of relapse is not great. In the case of Benign tertian even where all the above conditions are fulfilled the danger of relapse is much greater. The combined infectio n is a really formidable disease requiring long-continued and careful treatment.

CLIMATOLOGY.

The average annual rainfall in the Federated Malay States is about 100 inches. There are no well marked seasons and the total rainfall is in most years fairly evenly distributed over the months except for an increase in the last few months of the year. Thus in 1914 on an estate which had a total rainfall of 106.81 inches, 52.61 inches, or 49.25% fell during the last four months of the year.

For the same year on the estate the total number of malaria cases admitted to hospital was 596, and of those 193 or 32.36% of the total accurred during the same four months - September to December.

In 1915 on another estate the total rainfall was 95.83 inches of which 34.41 or 35.9% fell in the period September - December.

The average number of malaria admissions for these wet months was 97.5 per month. The average for the previous drier months was 69.6. In 1916 which was an exceptional year in that 77% of the rainfall which totalled 100.81 inches fell during the first eight months of the year, malaria cases totalled 519 and of these 391 or 75.33% were admitted during the same months - January - August.

These few figures illustrate the connection that exists between rainfall and the prevalence of malaria. They also illustrate the uncertainty as to the distribution of rainfall of this country mentioned above. Despite this variability of the climate in the matter of rainfall a ~~serious~~ series of the records of rainfall and malaria cases collected over a period of five years shows that heavy rainfall is almost invariably accompanied by an increased incidence of malaria cases.

The explanation is probably to be found in the increased number of suitable breeding places for the mosquito together with the lowered resistence induced by the chills and frequent wettings which the coolies get while working in rain and the lowered atmospheric temperature which accompanies heavy tropical showers.

In order to determine the part played by climatic conditions in the epidemiology of malaria a graphic chart was compiled which showed parallel horizontally drawn curves representing/

representing - rainfall in inches, number of hours during which rain fell, hours of sunshine, maximum temperature, minimum temperature, and percentage of labour force in hospital with malaria. The figures under each of these heads from which the curves were drawn were noted daily and the record kept for a year on two estates.

The effect of atmospheric temperature on the malaria rate is well seen in the charts where the curve of minimum temperature can be compared with that of percentage of labour force in hospital with fever. During the first week of February in that year the curve of minimum temperature goes steadily downwards till on the 8th 66°F, a record for the year was touched forming a sharp spike in the curve.

The percentage of the labour force in hospital at the end of January stood at 0.8% where it had been for some time, giving a fairly level line to the curve indicating this percentage. From the first February the curve steadily rises as the curve of minimum temperatures falls till on the 9th, the day following the lowest recorded temperature, the percentage line reaches 1.9%.

That this is no isolated phenomenon is proved by other sections of these charts which show the same relationship between those two curves throughout the year.

In the hilly interior of this country, owing to the humidity,/

humidity, heavy morning mists are the rule and any lowering of the temperature produces a dangerous degree of chill in the scantily clad and sanitarily housed Indian coolie.

In a laudable enthusiasm for free circulations of fresh air the Government authorities recommend that the coolies on estates shall be housed in elevated lines and advise that the floor boards be left slightly open. The Indian of this class when he is his own architect always has an earth floor and there can be little doubt that it protects him to a considerable extent from these chills which so often are the precurser of an attack of fever.

The only other points brought out in these charts which sought to correlate the malaria prevalence to the weather is in the curve showing the number of hours during which rain fell each day and that showing the number of hours of bright sunshine. The fewer the hours of rain and the more the hours of sunshine the less malaria is found.

In other words the opinion so often expressed by those who have long resided in these parts that dull wet weather is productive of an increase of malaria is supported by evidence obtained from accurate records. These findings are confirmed by the commonly observed connection between malaria and the rainy seasons in all tropical countries where such seasons are well marked. The effect of atmospheric temperature has not had

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so much importance attached to it. Most writers seem to assume that the increase in malaria is wholly due to the increased breeding of mosquitos, leading to an increased number of new infections.

That the lowered resistance induced through chill leading to relapses plays an important part in such seasonal variations is further indicated by the fact that on the more hilly estates in this district though the number of mosquitos is distinctly less in the season of heavy rains owing to the frequent flushing out of the streams in which breeding takes place, the number of malaria cases is greater.

Heavy floods carry off all larvae to a distance before development is completed.

TREATMENT.

The inquiry as to therapeutics of malaria might well be regarded as a work of supererogation since the efficiency of the ordinary salts of quinine given in the ordinary way has been so amply demonstrated, but the inducement to try alternative medication or new and more effective methods of exhibiting quinine is considerable.

European patients, especially those who suffer from repeated relapses, are apt to chafe at the invariable prescription of the same drug and soon begin to discover innumerable ill effects, some real but most imaginary, which they attribute to the/

the quinine they are taking. Such patients seize with avidity on any new remedy or line of treatment which is brought to their notice and lend all the help which a lively faith can give to the new therapy.

In the case of Asiatics the difficulty is rather more serious.

It is caused by the existence of an universal belief in the medical humoral pathology. The existence of hot diseases and cold diseases and of remedies appropriate to each is as unquestioned as their religious dogma by the great bulk of orientals. So far as the writer has been able to ascertain the thermal classification of quinine depends largely on the excipient. The stage of high temperature in malaria, to believers in this scheme of pathology, is, of course, a hot disease and if a sugar coated pill be offered at that time one is suspected - sugar and all sweets being deemed hot - of wishing to add fuel to a fire that is already killing the patient. On the other hand liquid quinine solution to which no syrup has been added seems, owing to its bitter taste, to be regarded as cool if not actually cold. The uneducated oriental regards the ague stage as a separate disease and cannot understand the taking of one remedy for two ailments which belong to two opposite thermal categories. It is true that one can hardly hope ever to escape from the complications arising from such a system of pathology and its dependent therapeutics, yet it seems that something might be gained if the number/

number of palliative drugs could be increased or the methods of administering them modified. In order to begin de novo and in the faint hope that the natural protective forces of the blood might in time produce an immunity reaction sufficient to kill the parasite, The experiment was tried of giving no quinine or other drug during the malarial attack or between attacks.

Owing to its unpromising nature this experiment was limited to three cases which were chosen because of their tendency to regular relapses and their chronicity. They each had a simple benign tertian infection. The effect in each case was practically the same. On the first day the temperature remained high for a few hours, about 103 then fell. There was the usual clear day then another rise of temperature, more prolonged than the last with great discomfort and headache. Only two paroxysms of fever marked the first admission which, allowing for the one which caused them to be sent to hospital, would make three in all. In all three the first effect to be noted was a great reduction of the latent period. In the case of No.1. this was reduced from 18 to 12 days. After the first no quinine attack.No.2. from 25 to 8 days and No.3. from 20 to 4 days. The second attack showed a much more prolonged fever and the periodicity tended to become less clearly marked, the remissions to normal lasting only about six hours.

The patients suffered from almost continuous headache and some aspirin was given in order to alleviate this sympton and to quiet the insistent demands for medicine. After two attacks the latent period became shorter still and the condition became one of practically continuous fever. This soon became too severe to be neglected and the experiment had to be discontinued. It was a small and rather timid experiment but it showed that in adults at least the body would in too many cases be destroyed before the elaboration of an immunizing body could be completed. The extremely high infantile deathrate in untreated malarious communities ([redacted]) would seem to indicate that the same holds in the case of children.

In this study the value of any treatment was estimated by its power to stop relapses rather than its effect in causing parasites to disappear from the peripheral blood. Even untreated cases during the latent period show this absence of parasites.

The only drugs tested apart from quinine was arsenic, which was used freely and with indifferent results in ague before the discovery of cinchona bark, but which has a great reputation among, and a kind of fascination for, laymen in the tropics. This was given to fifteen selected cases including both benign and sub-tertian. It was given in the form of Liq. Arsenici Hydrochloriens in 10 minim doses thrice daily for eleven days. [redacted]. In no case did this treatment prevent relapse and in only one was the interval

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of latency increased to such an extent as to make it appear probable that his next attack was due to a reinfection. In two cases arsenic in the form of novarsenobenzol was tried. This was given intravenously and each case had one dose only.

The result was to break the attack of fever but relapse occurred in both. This is the result reported by practically all workers who have used this drug. Even where a series of doses has been given the effect appears to be the same. The following abstracts of some of the many reports which have been published during the past few years on this subject indicate the results of the research of workers in various parts of the world.

Falconer and Anderson[1] reporting on nine severe cases of sub-tertian treated by Galyl conclude that the combined Galyl and quinine treatment give results sufficiently encouraging to justify further trial but that it must be understood that the use of Galyl in no way abates the need for quinine.

Stein[2] working with cases from Albania reports that neo-salvarsan disorganised all forms of benign tertian parasites but had hardly any effect on sub-tertian.

Silatchek/

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1. Journal Royal A.M.S. 1918.July. Vol.31. No.1. Notes on treatment of sub-tertian cerebral malaria with quinine and Galyl.

2. Stein (Benno) Malaria parasiten und Neo-salvarsan Zweite Mitteilung Wein.Klin. Woch. 1917. Vol.30.

Silatchek and Falta[3] after treating over 800 cases of which 100 had neo-salvarsan and the others intravenous quinine conclude that in chronic malaria neo-salvarsan is of very little use and much inferior to intravenous injection of the bi-hydrochloride of quinine.

They end their report with the significant remark that with either method of treatment a prolonged course of quinine by the mouth is advisable.

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3. Silatchek (Karl) and Falta (Karl) Neo-salvarsan and intravenous quinine in chronic malaria. Munch. Med. Woch. 1917. Vol.64. No.3

An even more convincing report than any of the foregoing is that issued by [I]Messrs Stephens Yorke Blacklock Macfie and Carter in their studies in the treatment of malaria.

Their work was all conducted where reinfection as a cause of relapse could be definitely excluded and their experiments were controlled and observed with scientific precision. In giving summaries of the results of single intravenous injection of novarsenobillon in benign tertian cases they find that such injections control the febrile paroxysms and cause the parasites to disappear from the peripheral blood but that parasites reappear on an average of 21 days' c/f last clause with remarks above in this thesis on relapses in benign tertian.

The remainder of the investigations in the tempting but somewhat unfruitful study of experimental treatment were conducted with quinine in one form or another.

I. Anns. Trop. Medicine and Parisitology. No.16.

The great cost and the shortage of quinine during the early years of the war led to a trial of "Cinchona Febrifuge". This is the non-crystalline extract of red bark containing a mixture of the alkaloids. It was the only product obtained from the Indian Government Cinchona Plantations from their establishment till 1888 when Gammie discovered the process, then a trade secret of the Germans, for the extraction of quinine. It is a dirty brown powder difficult of solution. It was given partly in suspension in doses of 30 grains per day in three parts. This was used for many hundreds of cases and the results were equally as good as those obtained by the same dosage of quinine or its salts. It is not easily dispensed in an elegant mixture but the muddy crudeness and the tendency it had to remain long in the crevices of the mouth is a definite advantage in its use among coolies, since it resembles the complicated decoctions of simples which form a large part of their native apothecaries stock in trade. Cinchona febrifuge is less trying to the stomach than salts of quinine but is less rapidly absorbed and is not suited for grave cases where quick action is essential requiring the use of the intravenous or muscular route.

A series of quinine treatments were instituted using control cases. The controls all received 30 grains of the bi-sulphate daily in solution of tripartite dose by the mouth. The others were treated as under:-

(1)/

(1) Intra muscular injections only for eight days. 30 grains per day bi-hydrochloride.

(2) Intra venous injection only. Single dose, 10 grains.

(3) Combined intra muscular and oral administration 10 grains bi-hydrochloride by the former route and 30 grains sulphate by the matter for ten days or more.

(4) Fractional dosage by mouth after the Nocht Teichmann method.

Series (1) showed no special advantages over the oral route.

The repetition of a painful process which was resented by the patients and the risk of abscess of the buttock are disadvantages. It is a useful alternative method for the administration of quinine where vomiting is persistent and where gastritis is present, and is of the utmost value in such cases, but as a routine treatment it is unsatisfactory.

Series (2) intravenous. There were 12 cases treated by this method of which three showed a definite improvement and did not relapse again during the period of six months they were under observation. In two others the method failed to clear the peripheral blood of parasites after 12 hours and quinine had to be given orally. All the other cases relapsed and showed no change in the latent period.

This is the most promising modification of the methods of giving quinine that has so far been tried but it is difficult to be enthusiastic over the results so far published. These cases were given only one injection of 7 - 10 grains of the bi-hydrochloride of/

of quinine dissolved in normal saline but the results seem to approximate closely to those obtained by other workers whose methods were bolder.

The following extracts from the recent literature on the intravenous administration of quinine give the findings of other experimenters.

I. Messrs Carnot and de Kerdrel generalizing their experience of this method in cases of malaria from Macedonia state that the action of quinine in intravenous injections is quick and thorough but admit that such injections have no extraordinary effect on the more resistant forms of the parasite such as crescents.

2. Richet and Griffin in the Indian Medical Journal give their opinion that 'the intra-venous injection is the only hope in serious coma'. It certainly is the best for such cases.

I. Les injections intra-veneuses de quinine dans le traitement du paludisme primaire. Paris Med. 1917. Vol.7. No.1.

2. On the intra-venous injection of quinine in malaria. Indian Journal of Med. research. Vol.5. No.3.

Knowles after using this method in twenty cases states that it is the quickest and surest means of cutting short a febrile paroxysm but that 'it cannot be relied on to exterminate the parasites'.

Stephens, Yorke, Blacklock, Macfie and Cooper[I]. give a report of 127 cases some of whom were given one dose and some a series of six doses by the venous route. Their conclusions are that febrile paroxysms are cut short by such injections but that relapses take place after a time which is of the same length whether a single or a series od six doses have been given. In malignant tertian the parasites do not disappear.

The intensive treatment by combined intra-muscular and oral routes with 45 grains a day did not increase the latent interval or prevent relapses any more successfully than the ordinary oral treatment.

The method of fractional and interrupted dosing tried is a modification of that of Nocht and cinsists in giving small doses every two hours for a week, then an interval of a week when no quinine is taken and 1/50th. grain of arsenic is given thrice daily, then ten days on quinine again. It is described and recommended/

I. Studies in treatment of malaria. No.3. Anns. of Trop. Medicine and Parasitology.

recommended by Oechner.

I.His paper published in 1917 found its way into the local lay press and excited so much lay interest that one was forced to give it a trial. Like all such methods it requires close attention to a time table and diary and is most irksome in its application.

The ten patients (Benign Tertian) on whom it was tried protested vigorously at the continual waking up to take medicine and eventually all relapsed.

The various methods of interrupted and fractional dosage have been devised and advocated by continental workers, chiefly German, but in published reports so far issued the evidence of cure are insufficient and the palliative effects are not superior to those found by other methods.

The above experiments and an experience of 23,778 cases treated in the six hospitals under my care during the past ten years inclines me to the opinion that for the eradication of a severe and chronic infection of malaria something more than an occasional cinchonization of the blood is needed. Unless the natural pretective agencies of the tissues can be evoked to aid in the process by improving the general physical condition, quinine alone by whatever method given is unlikely to bring about/

I.Journal of the American Medical Association. March 17th 1917.

about a cure. It has to be remembered that the parasites abound in the deep veins of the liver, spleen and bone marrow where circulation is slow and that there is no evidence that quinine in sufficient concentration to seriously injure them ever reaches the parasites ~~x~~ in these remote fastnesses. It is equally true that quinine is the only drug which can be relied on for the treatment of the disease and that all the modes of exhibiting it here described have their special value in certain cases.

PROPHYLAXIS AND ANTI-MOSQUITO MEASURES.

The term 'quinine prophylaxis' as applied to the giving of quinine regularly to communities has been frequently used in an ambiguous way which has led to much confusion in the published reports of this procedure. In the strict sense of the term it ought to be restricted to quinine given to malaria-free individuals with a view to prevent their becoming infected. In an endemic centre such as that in which these experiments were carried out where infected anopheles abound this restricted form of prophylaxis can find little place.

The new coolies who are admitted month by month to the estate during the continuance of daily quinine dosing are the only examples of this form of prophylaxis. It was found that the incidence of malaria amongst these was invariably higher than/

than that obtaining among the older residents, so that the protection afforded by these daily doses varying from 5 to 10 grains per day was practically nil.

The method which was extensively tried on these estates might be termed the community protective treatment for the prevention of relapses. This daily dosing by quinine of all labourers was the favourite and practically the only preventive measure widely used in this country on estates prior to 1917.

The Government Health Department, which pays special attention to estate labourers, has power to compel employers to give this daily dose of quinine. The faith of that Department in this anti-malarial measure survived much longer than the writer's so that the opportunities for studying its effects were more frequent and longer continued than was wished for. The principal controlled experiment made on the writer's own initiative has already been [I]. published but may be briefly summarised.

An estate labour force was divided into two unequal parts according to occupation. The first body had an average monthly strength of 140.83 and were tappers, who are, generally speaking, of better physique and employed on lighter labour than the other body of an average monthly strength of 252.03. The latter were weeders and comprised all the juveniles and a higher proportion of/

I. Quinine prophylaxis in Malaria. British Medical Journal. October 26th. 1918.

of those who were past middle life than the first group. The housing and other conditions were otherwise identical.

The first group were given 10 grains every day for one year by a system which rendered the avoidance of the dose nearly impossible.

The second group got no quinine.

The percentage monthly incidence of hospital cases for that was from Group 1.....14.31

Group 2.....13.19

The following tables show the percentage of the labour force admitted for malaria during periods of daily quinine giving and while no quinine was given on several of the estates on which this method was in force at various times. These figures are extracted from the monthly health reports issued by me far each estate.

The percentages for the six months prior to the giving of quinine followed by those for the six months during which the daily quinine was given are shown.

ESTATE NO.1./

ESTATE NO.1.

1915. No quinine.

June,	July,	August,	September,	October,	November,	December,
14.41%	16.66%	29.04%	35.55%	27.2%	30.42%	26.6%.

Quinine giving, 10 grains per day, commenced in December.

1916. Quinine 10 grains per day.

January,	February,	March,	April,	May,	June.)
23.90%	20.42%	14.4%	30.40%	21.33%	16.21%

These results are not very encouraging especially when it is remembered that the latter half of the year is normally much more malarious than the first half.

ESTATE NO.2.

1916.

No Quinine.

April,	May,	June,	July,	August,	September.)
4.02%	3.70%	2.91%	4.05%	3.94%	4.47%

Quinine given, 7½ grains, on two consecutive days per week.

October,	November,	December,	January,	February,	March.)
5.63%	4.66%	3.81%	8.46%	3.9%	4.86%

ESTATE NO.3.

No Quinine.

(April.	May.	June.	July.	August.	September.)
6.53%	14.51%	10.15%	8.80%	8.74%	7.45%

Quinine - 10 grains daily.

(October.	November.	December.	January.	February.	March.)
8.82%	13.38%	14.47%	9.41%	10.90%	1291%

These are a few of the results which have been recorded. There were many other efforts made to obtain an abatement of the malaria rate by this means but none gave results sufficiently impressive to raise interest.

The literature of this subject is copious but the usefulness of that published prior to 1914 is marred by a lamentable lack of precise statistics in support of the conclusions so emphatically enunciated.

The great war which provided an abundance of material for experiment and gave a control unattainable except under conditions of military discipline has resulted in many accurate reports of very comprehensive trials of this method.

Treadgold[I] in a paper on the prophylactic use of quinine in malaria has given a useful digest of the literature published on this subject since 1880. Of 201 writers on the subject he finds that 134 are in favour of prophylactic quinine, 27 are in favour but with reservations, 40 are not in favour of it. Then follows the statement that half of these writers give no statistics, and only 34 have controlled their observations. Of 23 who practised on indigenes and controlled their experiments all favour the preventive use of quinine but he remarks that some of the statistics given are not impressive. Dr. Treadgold's own observations carried out on a body of 123 men of the Macedonian force who were infected and subject to relapses afford less equivocal evidence on the subject.

His table of results reads:-

Group.	No. Examined.	Number with parasites.
No quinine in latent intervals.....	26	 16
Taking 30 grains daily..	21	 11
Taking 15 " " ..	9	 6
Taking 15 to 30 grains bi-weekly.....	11	 3

Perhaps/

[I] British Medical Journal. May 11th, 1918.

Perhaps the largest experiment in this method ever reported is that by Messrs Rawnsley, Cunningham and Warnock.[1] The authors state that they consider prophylactic quinine useless because in one year 5 grain doses twice a week did not preclude a high occurrence of malaria, nor in the next year did ten grains twice a week, or 10 grains every other day, or 10 grains four days a week, or 10 grains every day. Of quinine given to prevent relapses after using the method on a whole army corps they say that its results are uncertain and disappointing.

The splendid and accurate work of Messrs Stephens, Yorke, Blacklock, Macfie and Cooper[2] affords further convincing evidence of the slight value of preventive quinine in ordinary dosage. Their table of results of prolonged treatment by daily doses is as shown:-

Quotidian dose in grains.	Duration of Treatment in weeks.	No. of cases.	No. of cases relapsed.
20	14 - 15	5	3
30	5 - 18	14	10
30	8	29	24
45	3 - 8	19	7

Even with these heroic doses which can only be taken by patients in hospital the number of relapses is very high.

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1. The prophylaxis of Malaria. Journal of Royal Army Medical Corps. 1918. Vol.31. Nos.1. - 4.

2. Studies in the treatment of Malaria. Anns. of Tropical Medicine and Pasasitology. Vol.2. No.4. May 1918.

From a consideration of the results here tabulated from these estates supported as they are by the extensive experience of workers in malarious military areas the conclusion is unavoidable that daily quinine dosing is not effective in controlling malaria or even capable of appreciably influencing it. This method is expensive and diverts both money and energy away from the only reliable anti-malarial measure, namely, mosquito control.

MOSQUITO DESTRUCTION MEASURES.

It was the success which attended the efforts at mosquito destruction in the Panama Canal zone which gave the first great impetus to this method of combating malaria. The publication of Dr. Malcolm Watson's book which described his work in Klang and Port Swettenham further stimulated interest and provided a local example of successful malaria prevention successfully accomplished by the same methods. Despite those and other reports of similar work elsewhere, little systematic anti-mosquito work was carried out on inland estates prior to 1915, and the haphazard oil spraying, or draining occasionally carried out, did not produce results sufficiently impressive to justify the outlay in the eyes of the planters.

About this period sub-soil drains were installed round the capital/

capital town of Kuala Lumpur and on one or two large estates in that district.

The capital outlay in putting in these drains is large, and the cost of maintenance , if not high, is constant owing to the frequent heavy rains which carry large quantities of silt into the pipes and choke them. On estates, the tree roots frequently damage the drains by penetrating into the pipes. This method is well suited to Government and Municipal areas where practically unlimited sums of money are available. It is not so well suited to estates where the sum to be spent on health preservation, while it may be generous enough, must not be so great as to prevent these properties from fulfilling their primary function, namely, to pay dividends to their owners.

This commercial feasibility is a necessary attribute of any plan for the improvement of health conditions particularly on young estates and in those which are privately owned.

The definite incrimination of Anopheles Maculatus as the principal malaria carrier on all except the coastal areas of this country and the study of the breeding habits of that mosquito gave the first promise that a method of mosquito destruction might be divised which would be effective and not too costly.

The study of the life history of Anopheles Maculatus first published by Dr. Strickland established the fact which had been noticed/

noticed by other observers that the larvae of this mosquito are not found in virgin jungle, nor where undergrowth dense enough to create a continuous shade over the water is present. It is one of the light loving species and the female does not oviposit in water to which the sun cannot get access. This at once supplies information as to the cause of the rapid increase in the number of malaria cases which had sometimes followed what were intended to be anti-malarial measures, such as the clearing and clean weeding of swampy areas in proximity to the coolie lines. Such places, so long as they were covered over with heavy undergrowth, were not suited to the prepagation of Maculatus but immediately they were cleared would become so. That the aversion to shaded water as a breeding place on the part of this mosquito is a stable characteristic is supported by the latest reports issued from the anti-malarial Bureau.

In two places where oiling of all fresh streams and seepage areas had been thoroughly done[I]. Dr. Hacker found Maculatus larvae in an old kerosine tin, though it does not normally breed in artificial containers, yet none were found in a jungle-covered stream near by.

These additions to our knowledge of the chief carrier and its habits greatly simplified the problem and at once gave direction/

I. Hacker (Dr.H.P.) Malaria Bureau Reports. Vol.4.

direction and precision to anti-mosquito measures which had previously lacked both.

In order to determine the extent of the problem on these estates a circular area comprised within a 40 chain radius, with the coolie lines as centre, was systematically searched for the presence of larvae.

The small shallow streams were first gone over and it was while working in these that many places previously unsuspected were found to be prolific in Maculatus. Larvae were found actively swimming about on the very thin film of water covering the green algae at the sides of these streams. A survey made of all the areas where water was oozing out from the surface even when no actual surface water had collected confirmed the fact that these places are equally as dangerous as pools and streams if not more so.

The fact that the most potent carrier of malaria had an antipathy to shaded water led to an attempt to eliminate this mosquito by allowing all places where it could breed to become grown over by secondary jungle or cover plants of various kinds. This method which had the merit of simplicity and cheapness does not succeed for several reasons. One of the principal of these is that to be effective the shade provided must be dense and must be uniform. The opening made by a water buffalo or even a wild/

wild pig going into the stream to wallow will allow a sufficient amount of light to the water to produce conditions favourable to Maculatus breeding.

The soil in such places when it has once been cleared cannot grow the requisite amount of overgrowth in less than from two to four years.

If full advantage is to be taken of the protection afforded by shade the jungle growing on all potential breeding places should be left unfelled at the time the estate is first opened, and each ravine or swamp so left must be efficiently fenced so as to prevent ingress of men or animals which would make openings in the undergrowth.

Another objection to the method is the danger of the spread of weeds from these areas caused by seeds being blown from them on to the cultivated fields.

After a trial for a period of approximately two years of this method combined with oil spraying in places where growth was not satisfactory it was decided to clear all vegitation from the breeding places and rely on oil spraying alone.

There still remains a number of very extensive swamps which have been abandoned for many years, some of them near to lines which keep very free of malaria. These have been preserved and afford good evidence of the protection which can be obtained where the undergrowth is sufficiently dense.

For/

For all other breeding places a film of oil on the surface of the water was relied on as a larvicide. This is chiefly produced by a knapsack sprayer carried round by a coolie specially trained for the work while another coolie carries the oil mixture from a large drum kept at the lines round which the work is being done.

As the normal time for the development of the mosquito from egg to imago occupies some ten days it is sufficient if each place is sprayed once a week. It is remarkable what a large area can be thus treated by two coolies working constantly if supervision is maintained.

On the largest of these estates, extending to nearly 4,000 acres, and having three sets of lines distant nearly a mile from each other, the whole area can be efficiently sprayed once each week by two men.

Owing to the habit A.Maculatus has of breeding in running water, springs, and seepage outcrops, several modifications of the spraying method were found needful in order to maintain a film of oil on the surface. One that is suitable to certain types of narrow hill streams consists of a can supported on an elevated platform and placed over the head of the stream. A continuous drip of oil is maintained by means of a screw tap and wick. These were first described by I.Orenstein and le Prince and/

I. Mosquito control in Panama.

and are good where frequent attention can be paid to them but this is necessary since the oil mixture is liable to clog the wick and stop the drip. The device found most useful as a substitute for spraying in running streams of small size, and more particularly in springs, consisted of a ball of cotton waste packed tightly and tied into a small bag made of sacking. These are soaked in the oil mixture for a few days laid on the spring or stream and anchored by a piece of thin wire to a firm stake.

The last precaution is necessary in order to keep the bag from being washed away when the stream is in flood. These bags produce a continuous film of oil which is carried wherever the water flows and will remain effective for days. At the end of that time the waste is removed and dried and a fresh oil-soaked lot put in the bag. When dry this waste is ready to replace the other lot.

The total cost of the oiling measure here described over an area of half a mile radius round each set of lines on the large estate before mentioned, including the cost of oil and other materials, labour and supervision, does not exceed one hundred dollars per month (one dollar equal to two shillings and four pence) which is about the same sum as 20 cases of malaria would cost if each required five days treatment in hospital.

Results.

ESTATE NO.1.

Systematic larvicidal oiling was commenced on this estate during October 1918 but had to be suspended on two divisions from March to October 1919. The malaria cases admitted to hospital during each month of 1918 and 1919 were as follows:-

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
18.	49	31	40	77	90	54	32	50	49	16	7	6
19.	23	33	50	50	64	72	80	100	66	54	59	51

These figures show a sharp drop in the number of admissions beginning in October 1918 when oil spraying was commenced and continuing during November and December 1918, but after January the figure again rises till about June, July and August when the number of cases exceeds the worst month of the previous year.

During 1919 a famine in the matter of rice was anticipated and the Government ordered that all estates must plant up a certain area of such food stuffs as could be grown locally with a view to supplying the deficiency in rice. On this estate the only available land which was conveniently situated consisted of two extensive swampy areas near to the two largest sets of coolie lines. These had been abandoned for nearly eight years and were covered by dense secondary growth.

This/

This was felled and cleared off and numerous drains dug in order to render the soil sufficiently dry for tillage. A large increase of malaria followed as the area involved became an immense breeding ground of Maculatus. An effort was made to oil all these drains but a drought followed and the water had to be utilized for watering the young crops, and oiling was suspended till near the end of the year when the crops had been harvested. Even when this could be again done the number of possible breeding grounds had been so increased that the previous degree of protection could not be attained.

On the one division which was continuously oiled and where no clearings were opened up there was from the commencement of oiling a steady improvement in the malaria returns. This is well shown by the admission rate per cent per month on the three divisions.

These are:-

	Division No.1. Continuously oiled.		No.2. Oiling stopped & clearings opened.		No.3. Oiling stopped & clearings made.
1918.	5.39%	...	8.95%	...	6.09%
1919.	4.26%	...	10.54%	...	8.89%

During the previous eight years of which the records are available this No.1. Division has never shown a similar difference in its percentage admission rate.

ESTATE NO.2.

On this estate oil spraying was commenced in January 1919 and has been continued since.

The total number of cases admitted for the two years previous to the commencement of oil spraying are given as a basis for the comparison.

	No. of Cases.		Percentage per month of labour force admitted for malaria.
No oiling 1917 -	506	...	3.59%
No oiling 1918 -	668	...	4.14%
Oiling 1919 -	337	...	2.64%
Last 12 months:- recorded:- -	347	...	2.85%

ESTATE NO.3.

Oil spraying commenced in November 1918.

	Total Cases.		Percentage incidence for month.
1917. ...	531	...	8.64%
1918. ...	604	...	11.01%
1919. ...	300	...	5.24%
Last complete year	180	...	4.42%

ESTATE NO.4.

Oil spraying was commenced in May 1918.

	No. of Cases.	Percentage incidence per month.
1917. ...	699 ...	18.32%
1918. ...	484 ...	11.84%
1919. ...	193 ...	8.27%
Last complete year	141 ...	6.22%

On this estate during 1917 the whole labour force had a dose of 7½ grains of quinine twice weekly on two consecutive days.

An experiment in mosquito proof screening at two sets of lines was also tried as a prophylactic measure. The quinine dosing was stopped after oiling had been begun. The mosquito proofing of the coolie lines was a failure through lack of co-operation on the part of the dwellers who took no trouble to keep door and windows shut during the hours when mosquitos abound.

ESTATE NO.5.

Oiling commenced July 1918.

	No. of Cases.	Percentage per month of labour force.
1917. ...	34 ...	6.29%
1918. ...	50 ...	3.53%
1919. ...	11 ...	1.79%
Last full year recorded	9 ...	1.46%

This is a small privately owned estate managed by the proprieter and has only one set of lines. The proprieter was an enthusiast for the method and exercised a rigorous personal supervision over the work.

These results attained by means of unintelligent labour, indifferent supervision and primitive apparatus seem to indicate that the object for which this study was undertaken, namely, to devise some means by which malaria can be reduced to such proportions as will prevent it interfering with the development of estates at a cost within the resources of even the smallest of them has been attained.

The efficiency of this anti-malarial measure is only limited by the difficulty of locating every breeding place within the area and of getting oil regularly and completely applied to it.

The danger from long flights by carrier mosquitos breeding outside the area is small. This has proved to be so in practice/

practice, and the experiments with stained mosquitos carried out by [1]. Orenstein and Le Prince at Panama support this conclusion. Mosquitos were caught alive at the breeding places and stained by means of a sprayer with watery eosin and then liberated. These were caught later in various forms of domestic mosquito traps. It was found from repeated experiments that very few mosquitos travelled over half a mile in search of food.

A precaution that should always be taken in the laying out of new estates is that permanent buildings should not be erected at less than half a mile from the boundary so that if anti-mosquito oiling has to be instituted the area to be treated shall belong entirely to the estate requiring it.

The conclusion deduced from this study and from the literature quoted is that no anti-malarial measure so far proposed can compare in its results with those which aim at the destruction of the intermediate host of the parasites, the anopheline mosquito and that the method of destruction of larvae by means of [2]. kerosine as here described is capable of controlling the incidence of malaria on Malayan estates.

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1. Mosquito control in Panama.

2. The larvicide consists of a mixture of one part ordinary kerosine and fifteen parts crude oil or 'liquid fuel'.

SUMMARY.

The results of this investigation and the views deduced therefrom are:

That relapses cause a large proportion of the invaliding in Malaria and that in the Benign Tertian type there is a definite periodicity in the incidence of such relapses, the period of latency being approximately three weeks.

New infections are responsible for over 50% of the hospital cases in communities exposed to the bites of Malaria carrying Anophelines in large numbers.

There is some evidence that the type of parasite predominating in infections is influenced by the type of mosquito carrier transmitting the infection.

The mixed infection by Benign and Sub-tertian parasites is the most chronic type of malaria, and the Benign Tertian is less amenable to treatment than the Sub-tertian.

Violent fluctuations in atmospheric temperature are productive of an increased incidence of malaria and these are an important factor in causing epidemics during the rainy season.

Quinine and its salts form the only reliable drug treatment for the control of malarial attacks but the exhibition of quinine is not sufficient in itself to produce sterilization of the patients blood.

The natural resistance of the patient must be increased by other means before cure can be expected.

For all uncomplicated cases quinine given per os in three daily doses of 10 grs each is an efficient treatment for adults.

Intravenous and intramuscular administration is of the greatest value in certain forms of the disease.

Salvarsan and analogous arsenic preparations form a valuable adjuvant to the action of quinine.

The administration of quinine in daily doses to malaria free subjects is not an effective preventative of infection and will not prevent recurrence in those already infected.

The draining of all surface water which could provide breeding places for mosquitos over all the inhabited area, is the only permanent measure for the eradication of malaria.

The/

The regular spraying with Kerosene of all surface water within a circle having a radius of 40 chains round the living quarters provides a cheap and effective means of controlling malaria on estates.

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